SECTION 16240

MOTOR-GENERATOR SET, 60 HERTZ (HZ)(POWER CONDITIONER)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the contract, including general and supplemental conditions, apply to this section.

1.2 SUMMARY

A. This section includes motor-generator set and associated control and protection equipment.

B. Related Sections: The following sections contain requirements that relate to this section:
1. 16111 – Conduit and Fittings
2. 16120 – Building Wire and Cable 600V and Below
3. 16191 – Supporting Devices
4. 16450 – Grounding
5. 16483 – Motor Control

1.3 REFERENCES: The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

A. AMERICAN BEARING MANUFACTURERS ASSOCIATION (ABMA)
1. AFBMA 9 (1990) Load Ratings and Fatigue Life for Ball Bearings

B. AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)
1. ANSI C2 (1997) National Electrical Safety Code
2. ANSI C39.1 (1981; R 1992) Electrical Analog Indicating Instruments

C. INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)
1. IEEE 115 (1995) Synchronous Machines
2. ANSI/IEEE C57.13 (1993) Instrument Transformers

D. U.S. DEPARTMENT OF DEFENSE (DOD)

1. MIL-STD-461 (Rev. D) Control of Electromagnetic Interference Emissions and Susceptibility
2. MIL-STD-462 (Rev. D) Electromagnetic Interference Characteristics

E. NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)

1. NEMA ICS 2 (1993) Industrial Control and Systems Controllers, Contactors and Overload Relays, Rated Not More Than 2000 Volts AC or 750 Volts DC
2. NEMA ICS 6 (1993) Industrial Control and Systems Enclosures
3. NEMA MG 1 (1993; Rev. 1-4) Motors and Generators

F. NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)
1. NFPA 70 (1999) National Electrical Code

G. UNDERWRITERS LABORATORIES (UL)
1. UL 467 (1993; Bul. 1994, R 1996) Grounding and Bonding Equipment
2. UL 489 (1996; R 1998) Molded-Case Circuit Breakers and Circuit-Breaker Enclosures
3. UL 506 (1994; R 1997, Bul. 1997) Specialty Transformers
4. UL 508 (1993; R 1997) Industrial Control Equipment

1.4 SYSTEM DESCRIPTION: Provide motor-generator set with accessories, auxiliary equipment, and associated work as specified.

A. Equipment Design and Construction

The motor-generator shall be designed and constructed so that no parts work loose in service and shall be built to withstand strains, jars, vibrations, and other conditions incident to shipping, storage, installation, and services.

B. Protective Device Coordination

Protective equipment shall be coordinated to ensure correct overload and fault clearing sequences. Provide recommended settings of adjustable protective devices.

C. Safety Features

Power transmission apparatus (belts, pulleys, couplings, etc.) shall be enclosed or properly guarded to prevent injury to personnel who might accidentally come in contact with them.

D. Environmental Conditions

The motor-generator set shall operate satisfactorily at rated three-phase loads under the following conditions:
1. Indoor Unit
   a. Ambient temperatures ranging from zero degrees C to plus 40 degrees C when operating
   b. Ambient storage temperature ranging from minus 25 degrees C to plus 55 degrees C
   c. Relative humidity up to 95 percent.

E. Design Data
1. Motor-Generator Set Calculations

Submit with explanatory data for calculations, listing applicable parameters, the formula symbol for each parameter, and applicable formulas plus the step-by-step calculations, as a minimum:
   a. Overload and fault clearing sequence coordination calculations and time-current characteristic curves of the system's low-voltage protective devices and schemes. Provide recommended settings of adjustable protective devices.
   b. Mean time between failure reliability calculations for:
      1) Motor generator set
      2) Bearings.
2. Motor-Generator Set Data Sheets

Submit motor generator set data sheets in conformance with the requirements for shop drawings. Include applicable values for 75 degrees Celsius (C) and 60 Hz operation.

a. Motor-generator set combined component characteristics
   1) Mean time between failures (MTBF) in hours: [_____]
   2) Overload capacity, satisfactory operating period:
      a) At 1.25 full load in minutes [_____]
      b) At 1.20 full load in minutes [_____]
      c) At 1.10 full load in minutes [_____]
   3) Efficiency:
      a) At 0.25 full load in percent [_____]
      b) At 0.50 full load in percent [_____]
      c) At 0.75 full load in percent [_____]
      d) At full load in percent [_____]
   4) Short-circuit capability at three times rated current in seconds or provide short-circuit capability on a per-unit basis and duration of capability in seconds [_____]
   5) Frequency characteristics:
      a) Steady-state regulation in percent [_____]
      b) Deviation change rate curve [_____]
      c) Transient limits envelope modulation in percent [_____]
   6) Voltage characteristics:
      a) Steady-state regulation in percent [_____]
      b) Stability from no load to full load +[_____] to -[_____]
      c) Sensitivity in percent from no load to full load +[_____] to -[_____]
      d) Drift over a 30-day interval for an ambient temperature range from 10 degrees C to 40 degrees C +[_____] to -[_____]
      e) Step-load change at 20 percent of full load +[_____] to -[_____]
      f) Full-load change +[_____] to -[_____]
      g) Recovery to the regulation band in seconds [_____]
      h) Modulation in percent [_____]
      i) Voltage unbalance, balanced loads in percent [_____]
      j) Voltage unbalance, unbalanced loads in percent [_____]
   7) Waveform characteristics:
      a) Total balanced load root mean square (rms) harmonics line-to-line in percent, line-to-neutral in percent [_____]
      b) Maximum balanced load, single rms harmonic of the fundamental at the steady state voltage in percent [_____]
      c) Deviation factor in percent [_____]
      d) Waveform oscillograph for all above conditions [_____]

b. Motor
   1) Make [_____]
   2) Model [_____]
   3) Type of motor [_____]
   4) Type of field [_____]
   5) Power factor, lagging [_____]
   6) Input rating in volts [_____]
   7) Frequency in Hz [_____]
   8) Full-load motor current in amperes [_____]
   9) Number of poles [_____]
   10) Full-load rating in kilowatts (horsepower) [_____]
   11) Synchronous speed in revolutions per minute (rpm) [_____]

c. Generator
   1) Make [_____]
   2) Model [_____]
   3) Type of generator [_____]

4) Type of field [_____]
5) Power factor, lagging [_____]
6) Output rating in volts [_____]
7) Frequency in Hz [_____]
8) Full-load generator current in amperes [_____]
9) No-load field current in amperes or field rating in volt-amperes [_____]
10) Number of poles [_____]
11) Full-load rating in kilovolt-amperes (kVA) [_____]
12) Synchronous speed in rpm [_____]

1.5 SUBMITTALS: Submit the following:

A. Shop Drawings
1. Motor-generator set fabrication
a. Indicate as a minimum, the certified outline, general arrangement (setting plan), and anchor bolt details.

B. Product Data
1. Motor-generator sets
2. Miscellaneous controls and ancillary control devices
3. Input/Output device
4. Protective control devices
5. Electrical instruments

C. Design Data
1. Motor-generator sets calculations
2. Motor-generator sets data sheets

D. Test Reports
1. Transient
2. Ground resistance tests
3. Submit transients test results as required in paragraphs entitled "Transient Test." Indicate on each, acceptable limits for voltage and frequency. For ground resistance test, submit results as required in paragraph entitled "Ground Resistance Tests."

E. Certificates
1. Manufacturer's Representative's Qualifications
2. Factory test data
3. Factory test schedule
4. Field test schedule
5. Submit evidence that the manufacturer's representative is qualified to provide specified services, as specified in paragraph entitled "Qualifications," in this section.

F. Manufacturer's Instructions
1. Motor
2. Generator
3. Control unit
4. Anchor bolt
a. Submit installation drawings for the above.

G. Manufacturer's Field Reports
1. Motor-generator set

2. NEMA MG 1. Submit 5 copies of each for motor-generator set. Include design tests, production tests, and conformance tests for approval before delivery of equipment to the project site. Manufacturer's tests shall be performed at the manufacturer's facilities and shall be witnessed by the Construction Manager or a representative of the Construction Manager. Tests shall conform to the test method requirements of NEMA MG 1, except for parts relating to electromagnetic interference, and repetition of voltage regulation and required voltage adjustment tests.

H. Operation and Maintenance Data
1. Motor-generator set
2. Submit operation and maintenance data.

1.6 QUALITY ASSURANCE

A. Certification

Certify final test plans and procedures, instrumentation used, and test reports. Comply with the requirements of the paragraph entitled, "Factory Test Schedules" including requirements for oscillographs, in paragraph entitled, "Transients."

B. Manufacturer's Representative's Qualifications

Evidence that the manufacturer's representative is qualified to provide specified services. The manufacturer's representative shall be qualified by knowledge of the design, installation, and testing of 60 Hz, low voltage systems, acquired through professional education and related practical experience.

1.7 Coordination

A. Coordinate layout and installation of Motor-Generator set and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, and encumbrances to workspace clearance requirements.

1.8 Delivery, Storage and Handling

A. Deliver equipment as a factory-assembled module with protective crating and covering.

B. Lift and support units with manufacturer’s designated lifting or supporting points.

1.9 Sequencing and scheduling

A. Coordinate size and location of pad and supports with building construction.

B. Coordinate size and location of structural-steel support members.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT: Conform to the standards and specifications herein. Electrical ratings shall be as indicated.

A. Bearings
1. Ensure reliability in accordance with AFBMA 9, Method L-10 calculations.

B. Molded-Case Circuit Breakers, Low-Voltage Type
   1. UL 489.

C. Electrical Instruments, Indicating Type
   1. ANSI C39.1; 108 mm(4.25 inch) square switchboard type accurate to within one percent of full scale or equivalent accuracy digital-readout type when specifically permitted. Digital meters shall have a minimal numeral height of 19 mm(0.75 inch) and shall provide a three-figure readout for values of less than 100.

D. Electromagnetic Interference Limits
   1. MIL-STD-461 for Class C2 equipment measured in accordance with MIL-STD-462.

E. Indicator Lights
   1. Self-contained, transformer-type operating at approximately 6 volts or miniature base-type operating at 12 volts and having minimum 14,000-hour life.

F. Insulation
   1. NEMA MG 1, Class F or H for synchronous machines, except that asbestos insulation is prohibited.

G. Nameplates
   1. Provide laminated plastic nameplates, a minimum size of 25 by 65 mm(one inch by 2.5 inches). Install on equipment, controls, instrumentation, indicator lights to identify functions and, where applicable, positions. Lettering shall be a minimum height of 10 mm(0.25 inch), engraved on a black-on-white matte finish.

H. Identification
   1. A metal nameplate not exceeding 125 by 155 mm(5 by 6 inches) shall be permanently attached by the manufacturer of the unit in a convenient location on the outside of the unit. Nameplate information shall include manufacturer's name and code identification number, required input and output voltage, frequency and current at full load, and total weight.

I. Reliability Calculation Data Base
   1. Provide failure rate calculation on the motor-generator and the electronic components.

J. Synchronous Machines
   1. NEMA MG 1.

K. Instrument Transformers
   1. ANSI/IEEE C57.13.

2.2 MOTOR-GENERATOR SET: Provide motor-generator set consisting of a motor-generator assembly for 60 Hz to 60 Hz isolation, exciter-voltage regulator system, voltage regulator with standard controls, protective devices, input/output devices, instrumentation, ancillary control devices, and other accessories as specified. Set shall conform to the applicable standards and specifications herein. Electrical ratings shall be as indicated. The complete equipment shall be enclosed in accordance with NEMA ICS 6, Type 1. Frames and enclosures shall be vermin-proof.

A. Rating

Provide set which has a calculated mean time between failures (MTBF) exceeding 15,000 hours when provided with yearly servicing and maintenance.

1. Motor
   a. Three-phase, 1,200 rpm, synchronous, with a 480-volt, 60 Hz rated input which maintains a minimum 0.9 power factor for loads exceeding 49 percent of rated load and a minimum 0.8 power factor for lesser loads or which maintains a unity power factor at full load and operates on a constant excitation regardless of load. Ensure adequate horsepower to drive the generator at 120 percent rated load with the output characteristics specified.
2. Generator
   a. Three-phase, 1,200 rpm, synchronous, with a 208/120-volt, 60 Hz, rated output having a minimum full-load capacity of 65 kVA at 0.8 lagging power factor when providing the output characteristics specified.

B. Capability and Performance Requirements
1. Overload Capacity
   a. Satisfactory operating time is based on not more than one overload per 24 consecutive hours of operation.

Percent of full load	Satisfactory operating time
125 percent	5 minutes
120 percent	30 minutes
110 percent	60 minutes

2. Efficiency of the Motor Generator

Motor Generator Set Rating in kW	Minimum Percent Efficiency			
	25 Percent Load	50 Percent Load	75 Percent Load	100 Percent Load
45-75	60	70	74	77

   a. The efficiency shall be at least 77 percent at rated load, 60 percent at 25 percent load, 70 percent at 50 percent load, 74 percent at 75 percent load, and 77 percent at 100 percent (rated) load.
3. Short Circuit
   a. When a three-phase symmetrical short circuit is applied to the unit, the unit shall be capable of sustaining at least 300 percent of rated current for not less than a 10-second duration or not less than the time required for the integral system protective devices to interrupt the fault.
4. Radio Frequency Interference
   a. Provide factory installed devices on synchronous machines to suppress generated radio noise to the limits required by MIL-STD-461.
5. Frequency Characteristics
   a. Input/output: Provide 60 Hz output at 60 Hz input.
   b. Steady-state limits:
      1) Regulation: Not to exceed plus or minus one percent
      2) Deviation change rate: Not to exceed values shown in Figure 5 of MIL-STD-704.
   c. Transient limits: Not to exceed values shown in Figure 5 of MIL-STD-704 upon sudden application or removal of full load at rated power factor.
   d. Modulation: Not to exceed 0.5 percent.
6. Voltage Characteristics

a. Voltage buildup: Initial voltage buildup shall be completely automatic.
b. Voltage adjustment: The output voltage shall be capable of being adjusted over a minimum range of plus or minus 10 percent from rated voltage.
c. Steady-state limits
    1) Regulation: Not to exceed plus or minus one percent
    2) Stability: Not to exceed plus or minus 0.5 percent from no load to full load
    3) Sensitivity: Not to exceed plus or minus 0.25 percent from no load to full load for a one-hour interval
    4) Drift: Not to exceed plus or minus 0.5 percent over a 30-day interval for an ambient temperature range of 10 degrees C to 40 degrees C.
d. Transient limits
    1) Step-load change: Not to exceed plus or minus 3 percent for step-load changes equal to 20 percent of full load
    2) Full-load change: Not to exceed plus or minus 16 percent
    3) Recovery time: Not to exceed 0.25 second for a recovery to the regulation band
e. Modulation: Not to exceed 0.5 percent
f. Line-to-neutral, phase-voltage unbalance
    1) Balanced load: Not to exceed one percent between individual line voltages
    2) Unbalanced load: Not to exceed 4 percent for a one-line voltage from the average of the three-line voltages with one-third rated current on one phase and no load on the other two phases.

7. Waveform Characteristics
    a. Balanced load
        1) Total rms harmonics: Not to exceed 2 percent line-to-line and line-to-neutral
        2) Maximum single rms harmonic: Not to exceed 1.5 percent of the fundamental at the steady-state voltage
    b. Unbalanced load, total rms harmonics: Not to exceed 4 percent, line-to-neutral
    c. Deviation factor: Not to exceed 5 percent.

C. Motor-Generator Set Fabrication

Octave Band Center Frequencies (Hz)	Sound Pressure Levels dB ref. (0.002 dynes/cm squared)
63	78
125	72
250	67
500	64
1,000	62
2,000	60
4,000	58
8,000	57

Provide a horizontal or vertical, motor and generator, an exciter-voltage regulator system, and necessary devices for control. Mount on a common rigid steel base with the rotor assembly statically and dynamically balanced so as not to exceed a 0.002 double-amplitude indicator reading. The noise level shall not exceed 85 decibels adjusted at a distance of 915 mm(3 feet) from the set and approximately one-half the set height.

1. Bearing Requirements

   Construct shafts using bearings with a minimum calculated 150,000-hour life when properly lubricated. Conform construction to the following requirements:

   a. Lubrication: Provide either a single lubrication reservoir for all bearings or individual lubrication reservoirs for each bearing. Use lubricant recommended by the manufacturer.

2. Synchronous Machines

   Brushless-type, self-ventilated, dripproof construction with windings which are impervious to oil, solvents, moisture, mild acids, and alkalies. Limit temperature rise to 110 degrees C above a 40-degree C ambient temperature. Ambient operating temperature range shall be as specified in the paragraph entitled, "Environmental Conditions," in this section.

3. Voltage Regulation System

   The voltage regulator shall stabilize the output voltage within one minute after start-up and shall remain within a total regulation band of one percent within the unit rating and over an ambient temperature range in accordance with the paragraph entitled, "Environmental Conditions," in this section.

4. Exciter-Voltage Regulator System

   Shall be a totally static system utilizing either one or two shaft-mounted, three-phase, silicon-diode bridge assemblies to supply the motor and generator fields. Control excitation with a solid-state voltage regulator stabilized against long-term drift and ambient temperature variation.

5. Dimensions

   Physical dimensions shall not exceed 72” long x 36” wide x 72” high.

6. Control Cabinet

   UL 508. Mount controls, indicating lights, protective devices, and instruments in the control cabinet. Wiring shall have ample service loops and be protected from abrasion. Secure wiring and wiring harnesses at least every 150 mm(6 inches). Identify terminals in accordance with the wiring diagram. All components shall be UL recognized or listed, and the control panel shall have the UL 508 label.

D. Input/Output Device Requirements

Fully-rated, three-pole devices for protection and control of 60 Hz input to the motor generator, for protection and control of 60 Hz output of the motor generator, and for disconnecting the 60 Hz motor generator set output from the 60 Hz load.

1. Input Circuit Breaker
   a. Provide an industrial-type input circuit breaker with thermal overload and short circuit protection. Circuit breaker shall conform to UL 489.
2. Input Motor Controller
   a. UL 508, NEMA ICS 2. Start and stop the synchronous motor with a synchronous motor controller. Equip with thermal overload units. Limit full-voltage starting current to 300 percent of running current. Controllers shall incorporate undervoltage and overcurrent protection. Provide protective schemes for protection of the field winding and rectifier assembly during starting or pulling out of step.
3. Output Disconnect
   a. Interrupt the 60 Hz output with all industrial-type output circuit breaker with thermal overload and short circuit protection plus integral control devices to provide suitable control voltage. Provide circuit breaker disconnect and fuse protection for the control circuit.

E. Protective Control Devices

Provide relays, instrument transformers, and circuitry on the generator's 60 Hz output as necessary to provide protective control. Design protection to meet short circuit and overload requirements.

1. Overvoltage
   a. Protect by tripping input/output devices for instantaneous overvoltage of 30 percent or more and for 10 to 30 percent overvoltage lasting more than 0.25 second using a relay having an inverse-time characteristic.
2. Undervoltage
   a. Protect by preventing the closing of the output disconnect until the output voltage is 95 percent of the rated output. If, after closing, the voltage decreases to below 90 percent for longer than 5 seconds, provide relaying to trip input/output devices utilizing a field-adjustable, time-delayed circuit with a range of from 4 to 10 seconds. Alternatively, provide an inverse-time-versus-voltage relay whose characteristics reflect those of Figure 7 of MIL-STD-704.
3. Reverse Power
   a. Protect by tripping input/output devices for reverse power in excess of 5 percent of the motor-generator rating.
4. Underfrequency
   a. Protect by tripping input/output devices for underfrequency in excess of 5 percent of the rated output frequency (380 Hz).

F. Miscellaneous Controls and Ancillary Control Devices

Provide heavy-duty industrial or switchboard-type devices for manual control and alarm and data indication on the control panel.

1. Manual Control
   a. Set control: Provide two red position lights. Connect lights to provide indications of set configuration and provide nameplates inscribed "Motor Generator On" and "Output Disconnect Closed."

b. Alarm reset: Provide an "Alarm Reset" pushbutton to silence audible alarms.
c. Push-to-reset: Provide a "Push-to-Reset" pushbutton to test indicator lights.

2. Alarm Indication
   a. Provide nameplates, safety devices, white indicator lights, and audible alarms for the following alarm conditions:
      1) Overload
      2) Overvoltage
      3) Undervoltage (audible alarm on tripping only)
      4) Underfrequency
      5) High winding temperature
      6) High bearing temperature
      7) Reverse power
3. Data Indication
   a. Provide on the control panel the following for data indication and control. Digital meters are permitted.
      1) An input voltmeter and an output voltmeter, each with a voltmeter transfer switch having three "line-to-line" positions and one "off" position. The voltmeter scale shall provide reading for at least 10 percent overvoltage. (Voltmeter shall be rated 1.0 percent accuracy.)
      2) An output ammeter to read full-load output in the upper third of the scale with an ammeter transfer switch having three "phase" positions and one "off" position.
      3) A digital output frequency meter, 50 Hz to 70 Hz scale, having a 60 Hz center with an on/off switch. Field calibrate so that a 60 Hz input to the motor provides a 60 Hz reading on the meter. Provide a digital meter accurate to plus or minus one Hz.
      4) A running-time meter, 99,999-hour, digital, full-scale.
      5) A motor-start, five-digit operation counter.
      6) Other instruments normally provided by the manufacturer.
4. Control Circuit Transformer
   a. A transformer with a fused, 120-volt, 60 Hz secondary shall be provided for operation of control and indicating devices. Transformer shall conform to UL 506.
5. Terminal Blocks
   a. Suitable, clearly and permanently labeled terminal blocks which are readily accessible shall be included in each separately mounted unit for the interconnecting wiring and for the power supply and load connections.
6. Lifting Provisions
   a. Provide two forklift openings at each end of the base and two lifting eyes at each end of the entire set meeting NEMA MG 1 requirements.
7. Heating
   a. Provide heaters of a maximum 1,000 watts in the motor generator frame to prevent condensation. Automatically deenergize heaters in the motor and generator when the set is operating, and automatically energize heaters when the unit is not operating.

G. Test Points
   1. A number of test points shall be provided and brought to a common location in the control panel. These test points shall be shown on the schematics and in the maintenance manuals. Each test point shall be clearly and uniquely labeled.

2.3 FACTORY TESTS

Perform the tests described herein at the manufacturer's plant. Test components by operating at 60 Hz to determine suitability for operation at the full 60 Hz nameplate rating.

A. Factory Test Data

1. Separate test plans and procedures from test reports. Submit explanations of the methods to be used in demonstrating the requirements. Define tests required to ensure that the system meets technical, operational, and performance specifications. Note milestones that the test requires, identifying equipment and personnel required. Identify the capabilities and functions to be tested, including the values and situations comprising the test. Provide recordings and readable data demonstrating that equipment tested meets the limits and operation characteristics specified. In addition, submit the following outlined data:

B. Factory Test Schedule

1. Submit plans and procedures for factory test at least 60 calendar days prior to scheduled delivery.

C. Motor Generator Set

1. NEMA MG 1, except for parts relating to electromagnetic interference and repetition of voltage regulation and required voltage adjustment tests. Phototype tests of this specific rating size with all options to match this unit for compliance with the performance requirements of the equipment are acceptable.
    a. Motor Generator
        1) IEEE 115, including the following
            a) Operate motor generator continuously at least 8 hours. Operate at least one hour at each load point (25, 50, 75, and 100 percent of rated load) and 2 hours at 110 percent of rated load at either 0.8 or 1.0 power factor. Record efficiencies and other relevant data during each load run.
            b) Insulation: Test from each winding to grounded machine frame with other windings grounded.
            c) Total harmonic content: Test at no load and full load.
            d) Transients: Test for short-term voltage and frequency transients occurring upon instantaneous removal of 50 percent and 100 percent load. Repeat each test three times.
        2) MIL-STD-461 for Class C2 equipment, except that the radiated interference measurements shall be made at a distance of 2 meters(6 feet). Suppress conducted and radiated electromagnetic interference so that the normal operation of communications and adjacent electrical equipment is not affected.

PART 3 - EXECUTION

3.1 INSTALLATION

Conform to NFPA 70 and ANSI C2 and the approved manufacturer's drawings, written recommendations, and directions.

A. Grounding

1. Grounds shall have a maximum resistance-to-solid earth ground of 5 ohms for low voltage systems.
    a. Grounding
        1) Ground equipment as shown.
2. Grounding and Bonding Equipment
    a. UL 467.

B. Manufacturer's Representative

1. Furnish a manufacturer's representative to place the motor generator set in operation and make necessary adjustments to ensure optimum operation.

C. Foundation for Equipment and Assemblies

1. Mount motor-generator set on concrete base. The top of the concrete base shall be approximately 100 mm (4 inches) above the finished floor. Edges above floor shall have 15 mm (1/2 inch) chamfer. The base shall be of adequate size to project at least 200 mm(8 inches) beyond the equipment on each side. Concrete work shall be as specified in Section 03300, "Cast-In-Place Concrete." Provide anchor bolts.

3.2 FIELD TESTS AND INSPECTIONS

Perform field tests and trial operations, and conduct field inspections. Provide labor, equipment, and incidentals required for the tests including load bank, except that the Construction Manager will furnish electricity. Provide the Construction Manager with 7-days notice, in writing, of the dates and times scheduled for tests, trial operations, and inspections.

A. Field Test Schedule
1. Submit plans and procedures for field test at least 30 calendar days prior to the field tests.

B. Test Conditions
1. The tests shall be made at atmospheric pressure and at room temperature.

C. Electrical Equipment and Materials Tests
1. Test procedures, inspections, and sampling shall be conducted as specified in the specifications referenced and as noted in the following paragraphs. Record test data.
   a. Instruments
      1) Instruments and instrumentation procedures to be followed shall be appropriate for the tests to be performed. Instruments shall be capable of measuring and recording or displaying test data at a higher resolution and greater accuracy than specified for system and equipment performance. The instruments and apparatus used for the tests shall be calibrated by an approved laboratory within 30 days of these tests. Verify calibration and adjustments of installed instruments furnished under this contract just prior to accomplishing field tests.
   b. Insulation Resistance Tests
      1) Perform on equipment as listed herein. Perform tests with motor-driven or rectifier-type insulation resistance testers, having a range of up to 500 volts direct current (dc). Disconnect equipment, including solid-state, which might be damaged by such tests before tests are made. Tests shall measure insulation resistance from line to ground. Test 600-volt class circuits and equipment, including current-transformer and voltage-transformer secondary circuits and equipment. Minimum acceptable values of insulation resistance of circuits and equipment shall be as recommended by the manufacturer.

D. Preliminary Operation
1. Place into operation equipment provided and installed. Make adjustments necessary to ensure proper operation, as instructed by manufacturers of the equipment. Lubricate

equipment prior to operation in accordance with manufacturer's instructions. Dry out motors before operation as required to develop and maintain proper and constant insulation resistance. Upon approval by the Contracting Officer, operate motor generator sets under the supervision of the manufacturer's representative at varying loads throughout the load range to demonstrate that operation is proper, that temperatures are normal and within the specified limits, and to ensure that the units are ready to carry the test loads specified in the paragraph entitled, "System Acceptance Tests," in this section, without damage to the components.

E. System Acceptance Tests

1. When installation is complete and in operating condition, perform tests to ensure that equipment is functioning properly. Run each unit continuously for a minimum of 2 hours at rated 0.8 power factor load before performing operating tests. Perform three separate operations on each device. Tests shall include, but not be limited to, the following:

   a. Operate one unit at one-half load for 15 minutes. Provide additional load, and increase the load in several increments until unit is fully loaded. Adjust load again until unit is at one-half load. Step load the unit to full load. Record results.

   b. Control operation checks during field testing: During testing, perform operation checks of which controls are capable to ensure that controls are functioning satisfactorily. Each instrument on the set panel shall be observed at several points during the tests to ensure that instruments are functioning properly. Record results.

   c. Perform operating test on each protective device and protective scheme to ensure that devices and schemes are functioning properly.

3.3 TRAINING

Furnish a representative of the equipment manufacturer to field train Construction Manager personnel. The field training period shall be limited to one 4-hour period and shall be scheduled with the Construction Manager at least 2 weeks in advance.

END OF SECTION 16240